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ABSTRACT

A model syllabus is presented for promoting literacy in information technology for elementary and secondary school teachers. In the syllabus, information technology is defined, and educational implications of new information technology are discussed in terms of the societal context, and teaching and learning. Educational uses of the new information technology are outlined. Ways in which to introduce new information as well as to promote literacy in information technology in pupils are considered. Practical suggestions are given for courses to help teachers improve their literacy in the information technology field. Courses include: (1) information technology and society; (2) practical work with applications software; (3) introduction to problem solving by algorithmic means; (4) introduction to the architecture of information technology systems; and (5) methodology of teaching information technology. (CB)

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PREFACE

The ATEE Working Group on New Information Technologies offers, in this paper, a model syllabus for what we have called "Literacy in Information Technology for all Teachers".

In the United States of America a great deal of thinking currently goes into the definition, requirements and implementation of the concept Computer Literacy. The ATEE Working Group on New Information Technologies feels that Europe can learn from such ideas but that it is also possible to add to them, thereby arriving at a notion of literacy in information technology that is tailored to European needs and perspectives.

The model, which the Group presents here and which draws on ideas developed by our colleagues in The Netherlands (1) (2), is intended to serve as a basis for discussion, is open to revision. The debate is an important one, and contribution to it is warmly welcomed.

Manchester in March 1984

Rhys Gwyn
Chairman of the Working Group

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(1) Leren over informatie technologie, noodzaak voor iedereen, Adviescommissie Onderwijs en Informatietechnologie, Den Haag, 1982.

(2) Structuurplan nascholing VO, PAO-Informatica, Amsterdam 1983.

DEFINITION : Information Technology

Information Technology comprises

> the methods and technical means of capturing, storing, processing, retrieving and transmitting both data and the information borne by the data,

thus enhancing man's knowledge and extending his capacity to control technical and social processes.

Within information technology, computer and telecommunication technology play an important role at the present time.

I INTRODUCTION

A Educational Implications of New Information Technology

The overall educational implications of New Information Technology (NIT) are, to say the least, complex to identify, and no one paper on the subject can claim to be definitive. What we offer here, in an attempt to focus thinking about responses required in teacher education, are some guidelines which we consider valid, and an analysis which we hope will be helpful in the development of the required responses.

The educational implications of the NIT may first be seen as falling into two broad categories. First, there are those factors which impinge on the societal context within which education systems exist; second, there are the factors which affect the processes of teaching and learning. There are additionally, implications for the content of what is taught, but we begin by identifying some perspectives on each of our two main categories.

1. The Societal Context

It is widely acknowledged that education should prepare pupils for a future "Information Society" in which, for example:

- the daily functioning of citizens is highly dependent on the use of data and information, and therefore on dataprocessing and communication equipment;
- the automation of routine actions and processes will influence daily life and work, and affect the existing distribution of power in society;
- human beings will have to adapt themselves time and again to far-reaching processes of change; this will require great flexibility in mankind's reasoning capacity and power to act.

Pupils will need to be able to function in such a society, to assess a multitude of incoming information, and to understand applications of information technology in work and society. This assessment requires not only basic knowledge and skills, but also a critical attitude to

both the new technologies and to their uses. While it is possible that education will continue to lose its importance as a process for the transfer of knowledge (in the sense of factual acquisition), it may well gain in importance for the development of pupils' thinking capacities and of their insight into structures of, and relations between, data.

2. Teaching and Learning

It is evident to us that education will be more and more permeated by information technology as an aid to the teaching-learning process. Whatever aspects of those processes we consider, it is difficult not to see ways in which the appropriate use of information technology could contribute to, and enhance, what is done. This may well have very far-reaching consequences, and is likely to call in question a number of important assumptions, long held, about the nature of the educational system. Some such questioning will be very challenging, but will offer, we believe, some very positive directions for educational development. For example, learning opportunities for all will be enhanced if education is progressively liberated from its dependency on level, time, place and age, so that the concept of lifelong education (éducation permanente) becomes much more realisable. Such applications of information technology to education will have far-reaching consequences for content and for form.

It is our view that both of these areas - response to the societal implications, response to the implications for teaching and learning - require the closest possible examination. They postulate, in the nature of things, large and extremely complex scenarios, dependent upon a very wide range of developments in the economic, social,political and cultural spheres as well as the educational. As a consequence, to enter into any kind of study of these areas is to grapple with a number of unknowables and to enter the field of futures prediction.

We believe that this effort needs to be made. It is particularly important that this happens if we are not to allow educational development to lag hopelessly behind the development of the technological means at its disposal. We propose to engage, in our work as a Group, with

preliminary analysis of the directions developments might take, and with identification of positive actions which might be launched.

This however is not a task to be undertaken lightly. There is the overriding question of its complexity; there is the fact that some of the developments called for will be, without question, highly expensive to install, and there is lastly the important consideration that changes in the educational system, especially those of a far-reaching nature with consequent implications for the children concerned, need to be pre-examined very carefully indeed. All of these factors counsel caution, though we are firmly of the view that the danger at present is, not that we shall rush headlong into irresponsible educational change but rather the contrary: that national authorities will concentrate too closely on relatively limited areas of development without engaging adequately with at least preliminary steps in the direction of the larger scenario.

This said, we need to state clearly what we intend in this paper. We believe that while the futures scenario requires a longer scrutiny, it is now possible to identify a number of areas in which practical steps can be taken in a manner which will advance development without invoking insoluable problems.

We have therefore engaged here - given the nature of our professional interests - with the construction of one particular contribution to the taking of such practical steps. A considerable number of developments, at national and institutional levels, have taken place in the field of teacher education in respect of the NIT and we, all of us, as members of the Group, have individual experience of such developments. We now feel that it is possible to identify a broad strategy, based on our shared experiences and our analysis, whereby teacher education might approach some of the challenges posed by the NIT. Since these challenges are so new to teacher training institutions and staff, we believe that our thinking, presented here in the form of a model syllabus, may well contribute to development.

We emphasise that our ideas are not offered in any prescriptive manner. We are conscious that each country has its own modalities of teacher training, and that our analysis is to be seen primarily as a focus upon

the issues to be faced. In constructing this analysis we have concentrated, not on the larger-scale implication mentioned earlier in this section, but upon what is currently known about the educational uses of the NIT. We find that these give a practical and realistic orientation to analysis, and it is to these that we now turn.

B Educational Uses of NIT

It is possible to identify four classes of educational use of NIT. These are:

- learning about information technology
- learning with the aid of information technology
- learning by means of information technology
- information technology as an aid to school management.

We deal with each of these in turn, first in outline only.

1. Learning about Information Technology

Here, information technology itself, in the largest sense, is the subject of study. For our purpose, we suggest an analysis of the territory to be covered based on a four-stage progression from the environment in which the NIT exist to the "machinery" of the new technologies. Thus we have:

environment - Social Impact
- Application Systems
- Problem solving and Program Design

machines - Architecture of Programs and Machines

This, clearly, is a strcture for analysis and is not meant to suggest an order in which the subject matter should be broached.

2. Learning with the Aid of Information Technology

We here think of information technology used as a further aid to the learning process, just as we use a blackboard, a hand calculator, or an encyclopedia. Currently, this aid comes in the shape of the computer, which can be used as an aid to arithmetic, language teaching, information retrieval, graphical representation, text processing, and so forth.

Examples of such functions include the performance of extensive

calculations, or statistical analysis of sets of data, function and model evaluation, simulation of laboratory experiments and of "real life" processes, visualisation of abstract concepts and of numerical results, text processing, information retrieval (including item banking and item generation), and test marketing. In all of these instances, the computer is used as a support or a resource, but is does not provide the teaching modality.

3. Learning by Means of Information Technology

In this category, information technology is used as what is called Computer Aided Learning (CAL) by many writers. When the computer is used in CAL, the learning material is (to a large extent) stored in the computer, individual students/pupils have learning experiences in interaction with the computer, and/or a program provides learning materials, possibly by taking the progress of the student/pupil into account. Perhaps Computer Managed Instruction (CMI) can also be included under this Reading. When the computer is used in CMI it supports management and steering tasks for the learning processes; pupils' learning performances, for example, are monitored.

This is a rapidly growing area. It is a point at which we are in contact with some of the wider implications of NIT, for instance, Artificial Intelligence, especially expert systems development as mentioned in Section A above.

4. Information Technology as an aid to School Management

In this area, information technology is used to support not only financial and personal accounting, but also information retrieval and other tasks for school management. There is in fact a close link with CMI, in that the ability of the computer to store not only objective data but also diagnostic information concerning pupils' learning progress will introduce a new sophistication into the organisation of school. We feel that developments in this area should not be dismissed as "purely" administrative, since we believe that it has an essential contribution to make to educational development.

C. New Information Technology: a Strategy for Introduction

In the report "Computer Education in Six Countries: policy problems and issues"[1] it is stated in the summary:

> "None of the countries whose computer education programmes have been discussed in this report have solved adequately all the problems which these programmes pose, from provision of suitable hardware to teacher training and appropriate curriculum development. This prompts a question ... can computer education be introduced into existing schools on a solid basis at all, or does the whole school concept not have to be changed first? The advent of new information technologies is a quasi-revolutionary phenomenon, and it is worth asking whether it can be assimilated by the traditional institution called "the school" (or the university) or, whether (as stated by R. Gwyn) our education system will "recognize that new information technologies offer totally new ways of organizing learning and teaching.
>
> An analysis of experience in the six countries considered here does not provide an answer to this wuestion ... The picture ... is a mixed one. Moreover, the long history of most educational systems shows that they can adopt to and absorb even the most radical technological and social changes. Insisting on problems and difficulties ... means searching for solutions with a view to overcoming them and contributing to the necessary adaptation ... In all countries, indeed, human, social and political problems are more important than technological ones ... As soon as we say that the main questions are essentially human, social and political, we implicitly state that they are complex."

We regard these remarks as central to our argument. Their implication, to us, is clear: it is imperative that, as urgently as possible, we orientate as many teachers as possible to the impact of the new technologies upon their professional practice and the context in which they work.

The priority, as we see it, is a strategy to help all teachers understand the new technology and use it appropriately. This is a task for both initial and in-service education. That is to say, of the four classes of educational use of NIT identified in Section B above, we place our immediate emphasis on B1, Learning about Information Technology, and suggest that B2 - B4 (Learning with the Aid of IT, Learning by Means of IT, and IT/School Management) are topics of a secondary urgency

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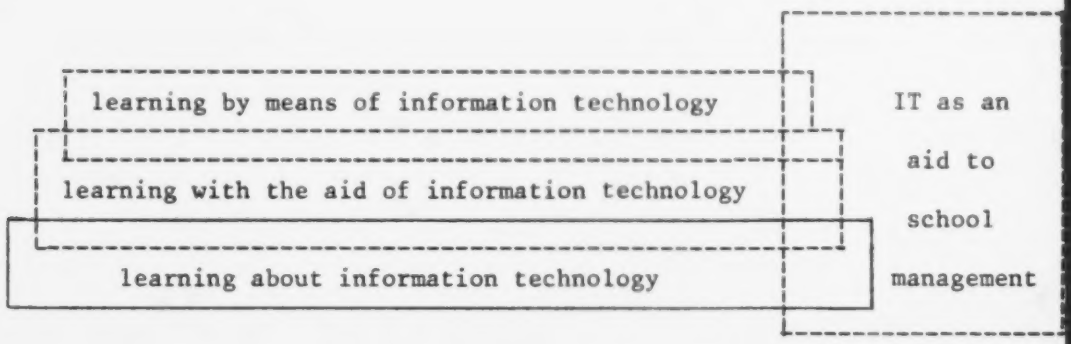
(1) Computer Education in six countries: policy problems and issues, Ladislav Cerych, Institute of Education, European Cultural Foundation, 1982.

for the immediate present.

That is to say, we see the above as an ideal model in which the knowledge of teachers about the different aspects of information technology in education is developed from a fundament of knowledge (literacy) about information technology. We schematise the process thus:


learning by means of information technology
learning with the aid of information technology
learning about information technology
IT as an aid to school management

This, of course, implicitly suggests a curriculum strategy, and it is appreciated that not all teacher education systems can incorporate (or may not choose to incorporate) such an approach. In those cases, relevant parts from this report could perhaps be synthesised with parts of the later reports which we are producing (on "Learning with the Aid of", and "by Means of" information technology) to devise an appropriate approach. It is not our intention to be prescriptive.

Thus we emphasise, to conclude our Introduction, that this paper deals only with a model for this fundamental phase - the acquisition of literacy, learning about IT. Our later reports, as we have said, will deal with the problems of preparing teachers to work with the aid, or by means of IT, and with IT in school management. Here we are concerned solely with teacher literacy in IT, and our model syllabus is focussed upon that topic alone. This does, however, not imply that the four categories (B1 - B4) are strongly separated: overlap (as indicated in the diagram above) will often occur.

II LITERACY IN INFORMATION TECHNOLOGY FOR ALL PUPILS

In order to be able to point out what experience all teachers should have with information teachnology, we need at least a notional idea of what experience the pupils of these teachers should have with information technology. In the following we focus on the content of literacy in information technology without implying that literacy in information technology should be taught as a separate subject; the teaching of literacy in information technology can be integrated into existing school subjects. Furthermore it should be understood that the learning content has to be operatized, taking into account age, ability and inclination of the pupils, the structure of the school system in the different countries and the time available.

We define the learning content of literacy in information technology on the basis of the hypothesis that:

- the learning content is intended for all pupils;
- for some of the pupils this literacy in information technology will be the only thing they will be taught about information technology; other pupils will use what they have learned as a basis for further studies. The learning content therefore has to be reasonably self-contained, but has to provide also a good basis for further courses about information technology;
- knowledge about information technology is rapidly changing; it is therefore desirable to present invariant knowledge to the pupils, i.e. knowledge that is not dependent on existing machines or software.

The central need in the teaching of literacy in information technology is to create insights which enable the pupils to develop a reasoned and balanced attitude towards information technology, and which enable them furthermore to react appropriately to situations in which contact with automated systems take place.

Our reasons for listing the areas in this order are based on the idea that a conceptual line can be drawn from environment to machine, and that this line might be used as a structure for a teaching programme. On the other hand, it is not intended that this progression from society to machine will always or necessarily be the approach to teaching; often much of the learning content can be presented in a parallel and concentric fashion. It is the teacher, in his or her own situation, who will adapt the learning content and its presentation according to the needs of the pupils.

We now look briefly at each of these content areas, and offer a possible focus for each.

a. Social Impact

In any treatment of the social impact of NIT, the following aspects are of importance:

> the gathering, protection and integrity of data, information systems (use and evaluation), changing methods and quality of work, changing employment, influence on individuals and their cooperation, influence on organizations.

These aspects should be seen as dimensions of the learning content of b. (use of application systems).

b. Use of Application Systems

In the classroom this area will be closely related to consideration of a. above, Social Impact. On the one hand an overview should be given of application areas such as those denoted below; on the other hand pupils should work actively with available application programmes as much as possible. Possible areas include text processing (e.g. club correspondence, club journals, professional text processing), information systems (e.g. library information systems, videotext), process control (e.g. traffic light control, robotics), applications in education (e.g. drill and practice, use of simulation programs).

For each type of application, examples need to be given. Some of these will be closely related to the immediate environment of the pupil; others

involve stepping outside of this environment. Finding a motivation form does not seem to present problems.

Not only are very concrete "do it yourself" experiences possible, but also excursions e.g. to an automated design department or a library with an automated index.

c. Problem solving by Algorithmic Methods (Principles of Programming)

The aim here is to let the pupil gain some experience with algorithmic thinking, modular structure, strategies for problem-solving and systematic refinement of algorithms, and with programming in a sheltered programming environment.

The application summed up in b. "Use of Applications" should play a role in problem-analysis and problem-solving by algorthmic methods, especially in concretely demonstrating the finding of solutions for more complex, unstructured problems and enabling pupils to "program" solutions for simple problems in a sheltered programming environment.

Pupils need to be confronted with very diverse sheltered application environments (e.g. very user-friendly implementations of applications suitable for the pupils). The teaching material should be suitable and motivating for boys and girls, pupils oriented towards the exact sciences and pupils who are not, pupils from different cultural backgrounds, and so forth.

d. Principles of software and Machine Architecture.

The fundamental notion here is that of process, described in a program and executed by a processor. Other important concepts include: storage/ memory, the different levels on which one can interact with a machine (the total of hardware and software), data communication, and micro-electronics.

The aim here is to provide the pupil with models which enable him or her to understand the experiences in the interaction with the programmed "machine". It is very important to stress the idea that all results of computation are brought about as a result of data put into the computer by human beings.

Insight into the structure of a system requires the pupils to learn and work with black boxes.

III LITERACY IN INFORMATION TECHNOLOGY FOR ALL TEACHERS

A. Introduction

It may be useful at this stage - in what is necessarily a complex description - to use diagrammatic representation of our charting of the IT education "territory".

We take the opportunity of re-emphasising the fact that we are here dealing only with what we see as the first of four major perspectives on development; that is to say, we are focussing here on the implications of "Learning about IT", the other three, (Learning with the aid of IT, Learning by means of IT, IT as an aid to school management) perspectives to be dealt with in later papers. While discussing literacy in IT for pupils, we have further sub-divided this first perspective into four topic areas. The total structure is represented by Figure 1 below. The relative widths of the blocks do not imply differences in importance or in the amount of time to be spent on the different subject areas.

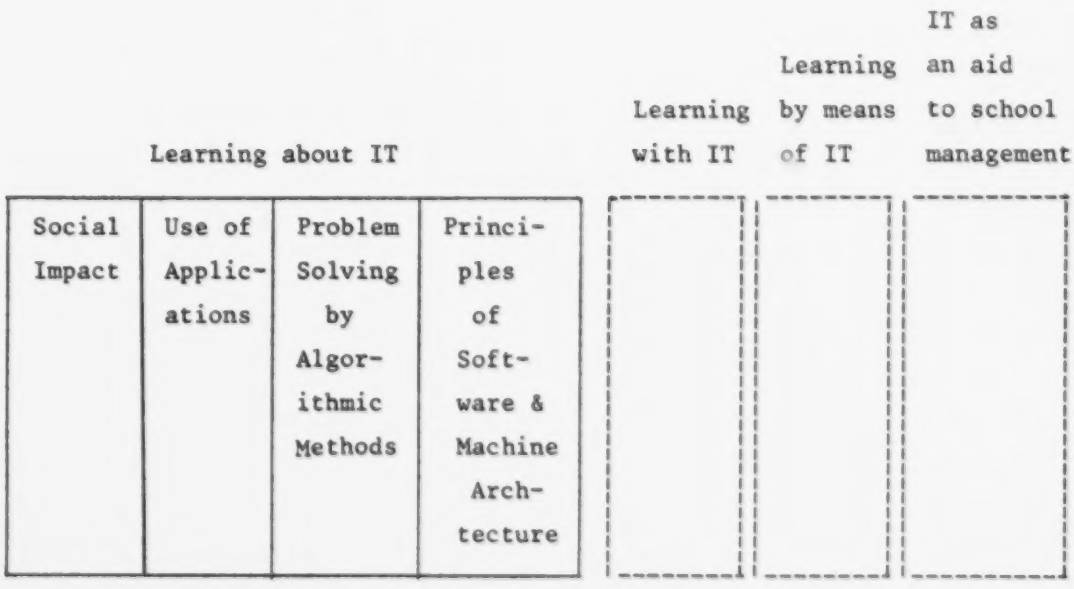

Learning about IT
Social Impact
Use of Applic-ations
Problem Solving by Algor-ithmic Methods
Princi-ples of Soft-ware & Machine Arch-tecture
Learning with IT
Learning by means of IT
IT as an aid to school management

Figure 1
Information Technology (IT) in Education

IT in education is all-pervasive; it is, as we have said, both medium and message, methodology and content. As a consequence, we have to consider the pre- (and inservice) needs not merely of those teachers who deal directly with IT but of all teachers.

An additional factor which stems directly from the fact that we are now moving away from a pupil centered analysis to a teacher (training) centered analysis, is that we must include also the teaching methodology of the subject-matter. Clearly, there are links between the didactical perspective and our second and third major perspectives (learning with the aid of /Learning by means of IT), but it does become possible to isolate out an identifiable area, which we see as that of a first phase: literacy in IT for all teachers.
Figure 2 maps out this phase.

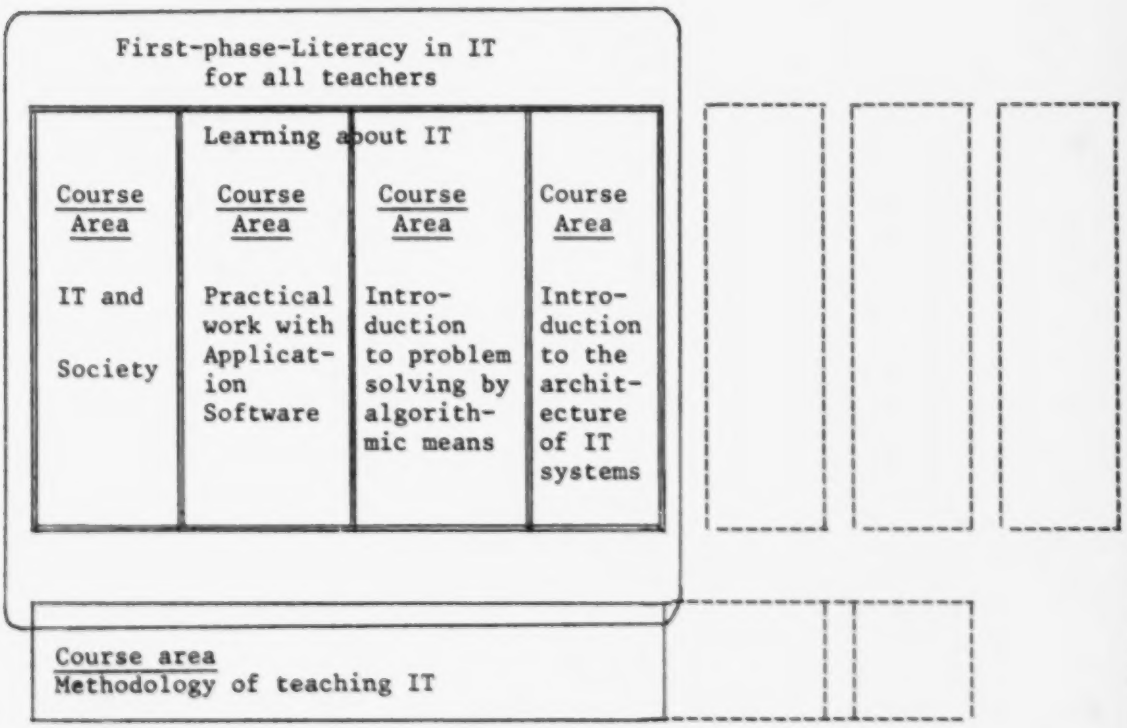


Figure 2
Information Technology (IT) in Teacher Education

As can be seen, the five course areas which we believe need to be covered in providing all teachers with a basic IT-literacy are:

i IT and society
ii practical work with applications software
iii introduction to problem solving by algorithmic means
iv introduction to the architecture of IT systems
v methodology of teaching IT

In the ideal case, the period of teacher education (pre-service or inservice) allows for enough time to cover substantial parts of these course areas that are not a traditional part of teacher education. As we have stated before, we appreciate that not all teacher education systems will allow for such an approach. In those cases relevant parts of the five course areas should be selected in the most appropriate way, e.g. to enhance courses on educational applications (learning with the aid of or by means of information technology). Later reports may offer ideas for such a selection.

Further more it can be envisaged that pupils now entering the educational system will be educated to be computer literate or literate in information technology by the time they are trained to be teachers. When selecting from the course areas this emerging literacy in information technology should be taken into account. And, of course, developments in information technology are very rapid and will influence the content of, and selection from, the course areas.

What is attempted here is to provide - at this particular point in time - a model syllabus that can help teacher educators in designing courses related to information technology.

Course Area - Information Technology and Society

Aims

The central issue in teaching "Literacy in Information Technology" is to bring about insights which enable (future) teachers to develop and present a reasonable and balanced attitude towards information technology. Students should gain insight into the value and importance of information technology for society generally, and into the consequences this technology may have for society, especially where educational applications of information technology are concerned.

A further aim of the course is to help students to develop a basic understanding of the ways and means of teaching about information technology and society.

The following is an illustrative outline of contents.

Content

- Information and Society
  information processing, the importance of information technology, the Information Society.

- Automation of information processing and process control
  in the management sector (including simulation), in the administrative sector, in the industrial sector and in the home (in devices such as washing machines, watches, TV-games).

- Influences of information technology on
  daily life, privacy aspects, upholding individuality, interhuman relationship.

- Work and Study
  changing the working methods, changing employment, quality of work, human-machine interface (ergonomic aspects), interhuman relationship and cooperation.

- Organizations (especially educational organisations)
  forms of organisation, structure of decision making, balance of power/working relations.

- Democratic and social structures
  structure of decision making, balance of power.

- International relations
  balance of power, control of multinational organisations.

- The sector of information technology
  organisation of the information technology industry, functions in relation with information technology, interests, social "responsibility".

Changes because of information technology should be viewed as part of a process of change. This process has a past, a present state and a future. In order to be able to understand this process it is essential that reasons for, and implications of these changes be clarified. In this judgement, values, norms and responsibilities play a role.

Presentation

The content should preferably be treated in as concrete a manner as possible, for example by working out relevant applications through games, cause studies or projects. A too theoretical approach should be avoided. Special attention should be given to the transfer of the body of knowledge covered in a class-room situation from teachers to pupils.

Course Area - Practical Work with Applications Software

Aims

The central aim is to acquaint future teachers with the range and use of applications software. This includes analysis and assessment of the introduction of these application systems in existing organisations.

Content

Applications such as the following should be included:

- text processing
- information systems (e.g. use of databanks)
- computing
- financial analysis (e.g. use of spreadsheets)
- process control

and educational applications such as Computer Aided Learning and Computer Managed Instruction (CMI). The analysis and assessment of application of NIT should also apply to their introduction into the school as an organisation.

In respect of each application, students need to see

- its practical utilisation
- possibilities for presenting (simplified) versions to pupils
- use as aids/means to learning
- possibilities for teacher contribution to design and maintenance.

Presentation

Practical work with applications software is an integral part of the course. In this practical work the possibilities and limitations of use of applications software in school should be highlighted rather than technical possibilities. Furthermore, invariant aspects of the applications software should be explored; details of the software actually used may be ignored.

Course Area - Introduction to Problem Analysis and Systematic Problem Solving by Algorithmic Means.

Aims

The aim of this course area is to give teachers a first introduction to problem analysis, systematic design of algorithms and simple data structures, and to the realisation of these algorithms in a higher programming language.

Content

- General concepts
  algorithm, object.
- Notation
  basic control structures, expressions, procedure, parameters, data structures.
- Top-down design of algorithms
  problem analysis, formulation of a solution strategy, top-down design by refinement, levels of abstraction.
- Design of typical algorithms
  screen control, e.g. screen-editor, pupil/machine interfacing.
- Realisation of algorithms in a concrete programming language
  syntax and semantics, implementation aspects, aides (tools) for the programming process.

Presentation

In the presentation of the course materials the top-down design of algorithms should be the central focus and not the details of the programming language or of the implementation.

Course Area - Introduction to the Architecture of Information Technology Systems.

Aims

In introducing the architecture of Information Technology the main issue is to present students (teachers) with a functional model of IT systems including fundamental concepts such as:

- process,
- object (data),
- process description (i.e. algorithm),
- interface,
- protocol.

Content

The lower levels of programmed systems structure, starting with the level of integrated circuits, should be treated briefly. This treatment should be aimed at the reduction of the "mystery" of information processing. As an example, the principle of the memory function may be discussed.

The levels of the conventional machine and of the assembly language should only be treated insofar as necessary to give a grasp of what goes on inside a programmed system and should not involve assembly language programming.

This level of the operating system should be discussed from a user's point of view: what functions are implemented and how these are used.

The level of interpreters and compilers should also be treated from the user's point of view and in relation to the operating system level.

The level of database systems should once again be discussed from the view point of what one can do or not do when using such a system. The relationship of this level with the previous one is of importance. The same applied to the level of application software.

Finally the treatment of the level of network architecture should give users a grasp of what goes on in a network.

Presentation

The presentation of the content should be as concrete as possible and involve practical work. The students have to see that their functional model "works", and that it allows them to think and speak about programmed IT systems in a down to earth, functional manner without any mystification.

Course Area - Didactics of Information Technology

It is clear that, in teacher education, the study of a given subject area calls also for the complementary study of the appropriate teaching methodologies. This is true of NIT as it is of any other area. Admittedly the subject matter is new, but its methodologies are becoming progressively clearer, as is the matter itself.

What we must emphasise here, however, is that we are concerned in this document with the general framework of understanding of NIT required by all teachers. It is implicit in our adoption of this perspective that we see the methodological implications of NIT in the context of the teachers's own subject area. NIT has already generated, in many subject areas, new ways of teaching and of learning, and we consider it more useful to deal with these separately in the contributions planned to follow in this series. These will deal, as we have indicated, with the potential of NIT as both an aid to teaching/learning and as a means.

The other implication of our adopted perspective is that the treatment of the teaching methodology of NIT sui generis more properly belongs to an analysis of the training needs of NIT specialist teachers, and it is in this conext (again, in a later publication) that we propose to deal fully with the topic. We recognise that, inevitably, the non-specialist who is introducing NIT into her or his teaching (whether as an aid or as an element of content) will need on occasions to teach directly about NIT. In such instances, the teacher concerned will need to draw on teaching methodologies appropriate to the NIT.

Nonetheless, we feel that the logic of our adopted structure indicates that the question of NIT methodology should be treated separately, in the context of specialist training. This view is reinforced by our acute

awareness of the different approaches to methodology adopted in our different countries; in the preparation of this document, for example, we have debated at some length the various connotations of the words "methodology" and "didactics". But whether or not the phrase "teaching methodology" in English covers the area typically called "didactics" in other European languages, we believe that the forthcoming reports will clarify the Group's view of the pedagogical implications of the introduction of NIT in education.

We emphasise once more that this document is in no sense intended to be prescriptive; this would be, in fact, contrary to the philosophy of ATEE. We put it forward, however, in the hope that our analysis will provide a useful framework for developmental discussion in our various countries; we hope that further documents in this series will also contribute to discussion of this most challenging of educational phenomena.

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